GENERAL RE-EVALUATION REPORT
APPENDIX C: ENGINEERING
SAVANNAH HARBOR EXPANSION PROJECT
Chatham County, Georgia and Jasper County, South Carolina

January 2012

ATTACHMENT 4
Project Cost and
Schedule Risk Analysis Report

US Army Corps
of Engineers
Savannah District
South Atlantic Division

US Army Corps
of Engineers®

SAVANNAH HARBOR EXPANSION PROJECT

GENERAL RE-EVALUATION REPORT

Project Cost and Schedule Risk Analysis Report

(CSRA)

Prepared for:

U.S. Army Corps of Engineers,
Savannah District

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ENGINEERING APPENDIX C – ATTACHMENT 4

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EXECUTIVE SUMMARY

Under the auspices of the US Army Corps of Engineers (USACE), SAVANNAH District, this report presents a recommendation for the project cost and schedule contingencies for the Savannah Harbor Expansion Project (SHEP) – General Re-Evaluation Report (GRR). In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted to identify potential project risks and establish project contingencies.

Walla Walla Cost Engineering Directory of Expertise (Dx) performed a risk analysis using the *Monte Carlo* technique, producing the contingency results and identified key risk drivers. During the risk analysis study and specific to the SHEP GRR NED Plan of 47-FT dredging depth, the most likely project baseline cost (at price level OCT 2010) approximated $483,719,000 (base cost excluding contingency). Based on the results of the risk analysis, the Cost Engineering Directory of Expertise for Civil Works (Walla Walla District) recommended a NED Plan contingency value of 25% or $120,930,000 for cost and schedule growth potential. The resulting baseline cost with contingency totaled $604,649,000. The tables below identify the NED Plan costs and contingencies. Schedule slippage risk is calculated at 1 to 2 years. Cost and Schedule Risk Model is based on 1.5 Year risk slippage.

Note that during the course of further Agency Technical Review, minor adjustments were made to the baseline cost estimate. The adjustments were not considered risk significant; therefore the cost and schedule risk analysis was not re-adjusted. The Total Project Cost Summary included the base cost adjustments, relying on a 25% contingency addition, commensurate with the results presented herein. This resulted in a new First Cost Budget Year 2013 total of $640,899,000.

The following table, ES-1, NED PLAN, portrays the development of contingencies and at various confidence levels. The final contingency was based on an 80% confidence level, as per USACE Civil Works guidance.

Table ES-1. Contingency Analysis Table – 47FT DESIGN DEPTH NED PLAN

Most Likely Cost Estimate	**NED PLAN : $483,719,000 - Base Estimate**	
Confidence Level	**Baseline $ w/ contingency**	**Contingency (%)**
50%	577,370,000	19%
80%	**604,649,000**	**25%**
100%	744,311,000	54%

The following table ES-2 portrays the full costs of the NED PLAN Code of Accounts based on the anticipated contracts. The costs are intended to address the congressional request of estimates to implement the project. The contingency is based on an 80% confidence level, as per accepted USACE Civil Works guidance.

Table ES-2. Cost Summary OCTOBER 2010 price level (NED)

SHEP – GRR 47-FT Design Depth		COST ($1,000)	CNTG ($1,000)	TOTAL ($1,000)
01	LANDS AND DAMAGES	14,885	3,721	18,606
06	FISH & WILDLIFE FACILITIES	169,815	42,454	212,269
12	NAVIGATION, PORT AND HARBORS	207,023	51,756	258,779
18	CULTURAL RESOURCES	11,132	2,783	13,915
30	PLANNING, ENGINEERING AND DESIGN	21,806	5,452	27,258
31	CONSTRUCTION MANAGEMENT	59,058	14,764	73,822
TOTAL PROJECT COSTS		**483,719**	**120,930**	**604,649**

Notes:
1) Costs include the recommended contingency of 25%.
2) Costs exclude O&M and Life Cycle Cost estimates (however, these costs are shown in the TPCS).

KEY FINDINGS/OBSERVATIONS and RECOMMENDATIONS

The key cost risk drivers identified through sensitivity analysis were the following Risk Events as discussed within the Risk Register
Risk Event No's:

- Risk Events I-37 & I-38 fuel increases from $2.70/gallon up to $6.00/gallon
- Risk Event I-20 & I-36 competition or competitive bid environment
- Risk Event I-41 Construct the Dissolved Oxygen Injection System
- Risk Event I-33 construction contract schedules for dredging

Together these risk driver's are the majority of the statistical cost variance

1. Key Cost Risk Drivers: The key cost risk drivers identified through sensitivity analysis such as fuel increases and competition are beyond control of the PDT; however, scheduling contracts to complete within environmental and weather windows, as well as establishing contract sizes may help in receiving more competitive bids. Construction of the Dissolved Oxygen Injection System has not been fully designed and carries various potential risks within cost. Design teams are recommended to work closely with cost development team to assure design of system is established for future construction within cost allowance. These should be considered in the contract acquisition process to lessen risks for these factors.

2. Risk Management: Project leadership should use the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

MAIN REPORT

1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers (USACE), Savannah District, this report presents a recommendation for the project cost and schedule contingencies for the SHEP GRR. It will also be integrated with the District Risk Management Plan.

2.0 BACKGROUND

The purpose of the SHEP GRR investigation is to determine appropriate future actions, if any, concerning navigation improvements to the Federal navigation channel at Savannah Harbor. This General Reevaluation Report documents the planning process undertaken to assess potential navigation improvements at Savannah Harbor. Improvements such as deepening the harbor, will result in fish and wildlife impacts such as salinity, wetland, and habitat changes which will require mitigation.

As a part of this effort, Savannah District requested that the USACE Cost Engineering Directory of Expertise for Civil Works (Cost Engineering Dx) provide an agency technical review (ATR) of the cost estimate and schedule. That tasking also included providing a risk analysis study to establish the resulting contingencies.

3.0 REPORT SCOPE

The scope of the risk analysis report is to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for all project features. The study and presentation does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the most likely Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the Savannah District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of problems, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering Dx. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by USACE Cost Engineering Dx.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The Cost Engineering Dx assembled a team, also relying on local Savannah District staff to further augment labor, expertise and information gathering. The Cost Engineering Dx team consisted of three (3) senior civil cost engineers.

The Cost Engineering Dx cost engineer facilitated a risk identification meeting with the SHEP GRR PDT originally in June 2008. All major disciplines participated which included operations, environmental, construction, hydrology, planning, real estate, programs, project management, geotechnical and design. Various discussions throughout the past 3 years have monitored and improved upon the risks identified and updated again through June 2011 and November 2011 (for OCT 2010 price level). The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the framework for the risk analysis.

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost Dx guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6 of this report.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

Checklists or historical databases of common risk factors are sometimes used to facilitate risk factor identification. However, key risk factors are often unique to a project and not readily derivable from historical information. Therefore, input from the entire PDT was obtained using creative processes such as brainstorming or other facilitated risk assessment meetings.

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Subsequent meetings focused primarily on risk factor assessment and quantification.

Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in Section 6 of this report for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 RISK ANALYSIS DOCUMENTATIONS

The following data sources and assumptions were used in quantifying the costs associated with the SHEP GRR project.

a. The Wilmington District Cost engineer, as part of the regional PDT, provided CEDEP and MII MCACES (Micro-Computer Aided Cost Estimating Software) files. The files transferred and downloaded on December 2011 were the basis for the cost and schedule risk analyses.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the October 2010 price level.

c. Schedules are analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and “Hotel” costs (unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay).

d. The Cost Dx guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

e. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk “watch list” for further monitoring and evaluation.

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Attachment A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

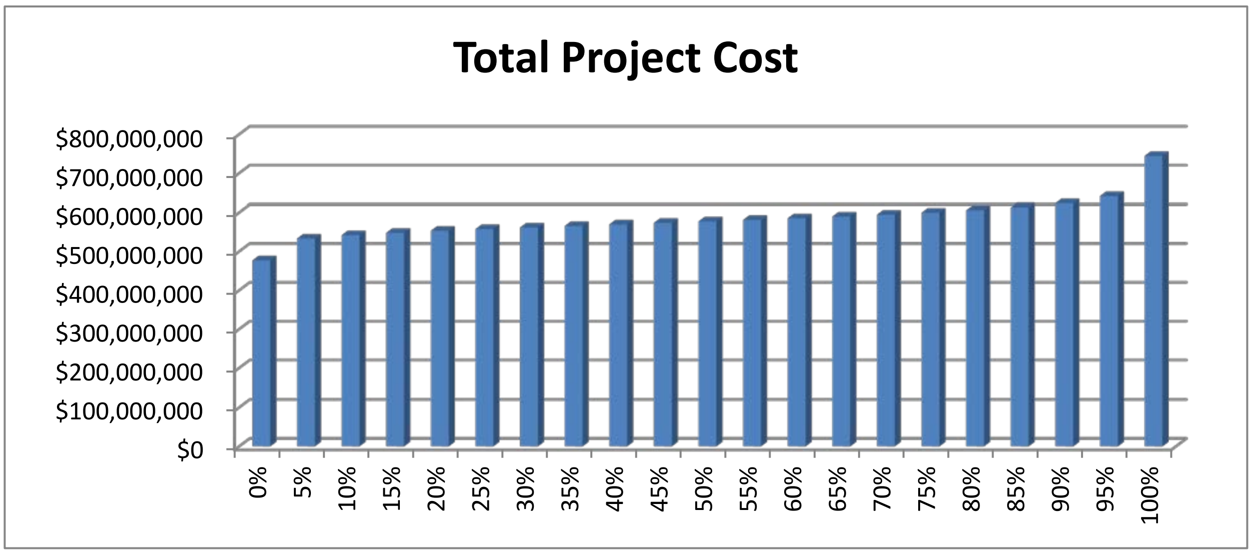
6.2 Cost Contingency and Sensitivity Analysis

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes only. Additional confidence level percentages versus Total Project Cost with contingencies are shown in Figure 1.

Table 1. Project Cost Contingency Summary – 47 FT Design Depth : NED PLAN

Risk Analysis Forecast	Baseline Estimate without contingency	Total Contingency[1,2] ($)	Total Contingency (%)
50% Confidence Level			
Project Cost	$483,719	$93,651	19%
80% Confidence Level			
Project Cost	$483,719	$120,930	25%
100% Confidence Level			
Project Cost	$483,719	$260,592	54%

Notes: 1) These figures combine uncertainty in the baseline cost estimates and schedule.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.



Confidence Level Percentage vs. Total Project Cost with Contingencies

Figure 1 - Total Project Cost

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 2 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Schedule growth and cost impacts were considered and included within the cost growth risks identified in the risk register.

7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

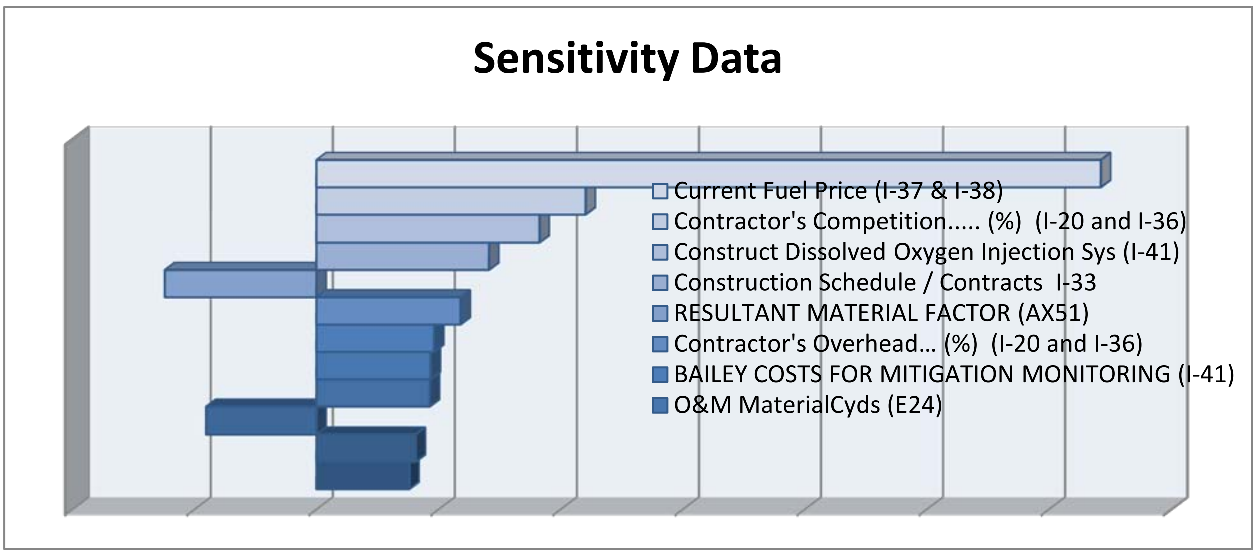


Figure 2 - Sensitivity Results

7.1 Major Findings/Observations

Project cost comparison summaries and graph are provided in Figure 1. Additional major findings and observations of the risk analysis are listed below. The key cost risk drivers identified through sensitivity analysis, Figure 2, are listed below and identified and discussed within the Risk Register (Attachment A) based on Risk Event No's:

- Risk Events I-37 & I-38 fuel increases from $2.70/gallon up to $6.00/gallon
- Risk Event I-20 & I-36 competition or competitive bid environment
- Risk Event I-41 Construct the Dissolved Oxygen Injection System
- Risk Event I-33 construction contract schedules for dredging
- Together these risk driver's majority of the statistical cost variance.

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, *4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

1. Key Cost Risk Drivers: The key cost risk drivers identified through sensitivity analysis such as fuel increases and competition are beyond control of the PDT; however, scheduling contracts to complete within environmental and weather windows, as well as establishing contract sizes may help in receiving more competitive bids. Construction of the Dissolved Oxygen Injection System has not been fully designed and carries various potential risk within cost. Design teams are recommended to work closely with cost development team to assure design of system is established for future construction within cost allowance. These risk drivers should be considered in the contract acquisition process to lessen risks for these factors.

2. Risk Management: Project leadership should use the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

3. Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

7.3 Summary

An overall project contingency of 25% is recommended based on statistical simulations for many elements within each cost and schedule item of the project.

Risk No.		Risk/Opportunity Event	Discussion and Concerns	Project Cost				Project Schedule		
				Likelihood*	**Impact***	**Risk Level***	**Rough Order Impact ($)**	**Likelihood***	**Impact***	**Risk Level***
Internal Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)										
I-1	Non-Dredge	Mitigation (McCoys Cut, etc.) Quantities could increase	Survey data is limited regarding existing depths -quantities could change up by 35%. Assumptions within the cost model as worst case considers an increased by 35% to arrive at High Range.	Likely	Marginal	Moderate	$2,581,000	Likely	Negligible	Low
I-2	Non-Dredge	McCoy's Cut - Material Type - rock encountered?	No Borings- Concern is production rate. Estimate uses slow excavation rate which would be conservative for everything but rock. No further risks were considered in the cost model.	Unlikely	Negligible	Low	$1	Unlikely	Negligible	Low
I-3	Non-Dredge	McCoy's Cut - Cultural Resources encountered	Unlikely Cultural Resource issues to be identified within McCoy's Cut, based on prior history of prior work activities. There were no risks evaluated in the risk register.	Very Unlikely	Negligible	Low	$1	Very Unlikely	Negligible	Low
I-4	Non-Dredge	Cultural Resources	There are significant Cultural Resources in the Wildlife Refuge, but only Cultural Resource cost identified is for CSS Georgia. High value is a judgment assessment of potential high cost added $1 M to the cost model.	Likely	Marginal	Moderate	$1,000,000	Likely	Negligible	Low
I-5	Other	Real Estate	95% accurate on their current real estate numbers; private lands will be acquired for mitigation and these properties could be developed. However, can't predict what cost will be in five years. Real Estate increases in near term are concerned low risk and no risks were evaluated in the cost model.	Unlikely	Negligible	Low	$1	Unlikely	Negligible	Low

I-6	Dredge	Real Estate taking due to over-swing	Inner harbor existing channel side slopes maintained at 3 horizontal to 1 vertical. Discussion: cutter-head dredge will have to over-swing. If over-swing by 10-12 feet, may cause eventual bank loss which is a taking of someone's land without compensation which has not been considered. Historically the district has told the dredge that no over-swing will be allowed, which means the toe does not get cleaned up. PDT needs to discuss with designers. Need to factor in risk for potential loss. Based on discussions the cost model included $5 M for potential risks.	Likely	Significant	High	$5,000,000	Likely	Negligible	Low
I-7	Non-Dredge	McCoy's cut - dredging disposal	Disposal area not identified - question came up on suitability of using Tybee going to -12A. Model did not include any risks as this is no longer part of project.	Unlikely	Negligible	Low	$1	Unlikely	Negligible	Low
I-8	Non-Dredge	Armored stone riprap material cost increase	The stone from a Georgia quarry would be hauled on a barge and placed by crane to close the connection. Cost of transportation is probably the main uncertainty. Some of the stone can come in by rail (only certain quarries have rail service). Cost model assumed material costs could increase by $2.6 M.	Likely	Marginal	Moderate	$2,606,000	Likely	Negligible	Low
I-9	Non-Dredge	Flow Diversion – McCoy's Cut quantities	Sheet pile and placing of armored stone for structure quantities based on 2002 USGS survey do not have a model of required structures shape. **Quantities were revised March 2010 and more confidence with these Cost model assumed increase in quantities by modeling 20% overall increase.**	Likely	Marginal	Moderate	$450,000	Likely	Negligible	Low
I-10	Non-Dredge	Submerged Berm, Filling Sedimentation Basin - rock vs sandbags cost	construct submerged berm that will retain the sediment coming down the stream on the Back River. VE team made a comment that rock could be replaced with bags of sand (10 tons each). 60-70,000 cubic yards of rock needed to raise bottom elevation from-40 to -9. Fastest velocity reaches 6 feet per second Tidal – twice a day. Cost Model of quantities and placement could possibly be reduced by $3.2 M	Likely	Marginal	Moderate	($3,176,000)	Likely	Negligible	Low

I-12	Dredging	River Industries - Impacted	Problems with industries on the river in past claiming Corps' dredging caused damage to docks and property, even though they are quite remote. Property was looked at, but not addressed due to view that it will not be impacted.	Unlikely	Negligible	Low	$1	Unlikely	Negligible	Low
I-14	Non-Dredge	Dissolved Oxygen Systems - scope	Systems roughly half of the cost of mitigation. Two cost estimates done. Tetra Tech did DO system – generating dissolved oxygen ($30 M) and CH2M Hill developed cost for site development ($13.5 M). The high (contingency) 30% and low range was 25%. Used 30% because the consultants had developed costs. Was scope missed? **Costs were updated 2010 and November 2011 - based on more accurate evaluation still believed to be moderate risk. Model assumed quantities could increase by approximately 15%**	Likely	Marginal	Moderate	$6,525,000	Likely	Negligible	moderate
I-17	Non-Dredge	Adaptive Management Measures	Only thing included in estimate is costs for mitigation monitoring of approximately$18 M. Of the $18 M, there is $6.7 M for adaptive management costs which includes removal of the tide gate's foundation sill ($2 M) and $4.7 M for other adaptive management. Discussion that removing the tide gate sill is not going to occur. **Costs have been updated and more detail added as of April 2010 and again in November 2011.**	Unlikely	Negligible	Low	$0	Unlikely	Negligible	Low

I-18	Non-Dredge	Chloride Concern and addition of Water Storage Impoundment	Concern: Deepening the harbor will cause the salinity to creep further upstream. This could alter chloride levels in an industrial water supply. The City's preferred option is for the project to provide a supplemental intake line 10 miles upstream ($35.9 M). Installation of a pipeline would require acquisition of private property. There may also be other viable mitigation alternatives. The question is whether this a true risk or not. The work is presently not included in project cost estimate. Modeling shows deepening would not cause much of an impact to the quality of the water at the intake. If ongoing studies identify this as a feature that is needed, it would be added to the project in the final report. Two determinations need to be made: 1. Is mitigation for chlorides required (predictions to be confirmed in studies yet to be completed), 2. If required, will it be funded under this study. If it is not required, then these costs should not be in risk analysis. If it is authorized separately and uses separate funding, it would not be a part of this risk analysis; otherwise it needs to be factored into the cost risk for this project. November 2011 raw water storage impoundment - was added to the project MOST likely COSTS. This significantly reduces the likelihood major cost increases. Of the costs within the rawwater storage impoundment, cost increases may be seen from parametric estimates for pumps and activated carbon silos. Cost analysis will consider changes to pump and carbon silo pricing - Model addressed in overall -10%/+20% factors of I-40.	Unlikely	Negligible	Low	~~$0~~	Unlikely	Negligible	Low

~~I-19~~		~~provide water intake/pond mitigation for chlorides~~	~~Concern: deepening the harbor will cause the salinity to creep further upstream contaminating the water supply with chloride. Solution storage pond to supply water in low flow times. The City now wants double the amount of water they originally requested. The option went from $38 M to $76 M on the storage pond. Question is whether this a true risk or not. Not included in estimate. If it happens would a different document be used to authorize the work or would it be covered in this report. Modeling showed deepening did not cause much of an impact. Two determinations need to be made: 1. is mitigation for chlorides required, 2. If required will it be funded under this study. If it is not required then should not be in risk analysis. If under separate funding, it would not be a part of this risk analysis; otherwise it needs to be factored into the risk.~~ See item 18 above	~~Unlikely~~	~~Negligible~~	~~Low~~	~~$1~~	~~Unlikely~~	~~Negligible~~	~~Low~~
I-20	Dredging	Bid competition and/or Contractor Profit	**Navigation Issues concerning contracts would include competitive bid environment and scheduling contracts. Model increased Contractor profit, overhead & contract schedules.**	Likely	SIGNIFICANT	High	Adjust profit Margin from10 to 25%	Likely	Negligible	Low
I-21	Dredging	Dredging - quantities	**Dredging - over swing/side slopes concern - Impacts quantities - slope stability report is to be provided to cost engineer. Model used overall change of -10%/20% as described in Item I-40.**	Likely	Negligible	Low	-10%to +20%	Likely	Negligible	Low
I-24		Dredging - Turtles	If too many turtles taken can cause dredging to stop 4 green 1 ridley. Model increased costs for additional MOB-DEMOB cost potentials.	very Likely	significant	High	$ 1,600,000.00	very Likely	Negligible	Low
I-25	Dredging	Dredging - Debris	Civil War cannon balls, Civil War mines, WWI ammunition, usual sprinkling of steel cables, pieces of concrete, etc. Channel last deepened in 1991-1994, cultural resources surveyed and magnetometer survey done. Estimate includes debris removal item based on historical data from last dredging. Cost model uses with one half of cost since not much debris is expected.	Unlikely	Negligible	Moderate	$ (844,000.00)	Unlikely	Negligible	Low

I-26	Dredging	Sedimentation-quantity	Estimate of total siltation cannot be defined and are looking at the cost for what is typically removed in a year; so they can add in what is not removed during the year. ~~Don't dredge every part of the river in a year cycle and don't get all the over depth. 2 million extra cubic yards.~~ Revised in model to consider -10% and +20% more material from O&M that may be in channel and cannot be funded through normal O&M process.	Likely	Significan t	High	Quantities in CEDEP range of 20% more	Likely	Negligib le	Low
I-27	Dredging	Other O&M	There is some initial O&M that has to be done to make this project work. It probably can be done during construction. ~~For instance, there is an $11.5 M advance maintenance feature offshore that they are going for approval.~~ Also, there is the CSS Georgia at $9.5 M. These features are adding up. Not sure if going through the normal O&M procedure these items would get approved. What is risk of project moving forward if O&M not approved? Funds may have to be obtained by deepening project. Model included O&M other than siltation at $5M or about 2.5% of dredging account.	Unlikely	Significan t	Moder ate	$5,000,000	Unlikely	Negligib le	Low
I-28	Dredging	Sedimentation-Weather	Off-shore work, putting material off Tybee there may be impact from weather that could increase costs. This is no longer part of the project and not modeled.	Likely	Negligible	Low	$1	Likely	Negligib le	Low
I-30	BOTH Dredge and Non-dredge	Construction Schedule / Contracts	Three contracts. One is the ocean bar, lower inner harbor and the upper inner harbor. Multi-year mobilizations. Estimate - <15 months one mob and demob; >15 months of dredging, two mobs/demobs; at ~24 months of dredging, three mobs and demobs. Pricing based on October 2007 - $3 M may be less months. Updated December 2011 using only 2-contracts for Inner & Outer Harbor. Additional contracts may still be required for multi-year mobs or funding constraints. All contracts may have to be delayed. Additional 2.5% of all costs were included in model for these risks.	Unlikely	Significan t	Moder ate	+$9,600,000 range to - $3,000,000	Unlikely	Negligib le	Low

I-31	Dredge	Disposal Dikes	Seven disposal dikes in area need to raise six to accommodate the material. Estimate - under disposal area requirements - $30,000,000 represents the cost to raise those dikes. It costs $5,000,000 to raise a dike six foot; If they have to be raised higher, the cost may be different. November 2011 more detail has been defined and cost were not modeled.	Unlikely	Negligible	Low	$1	Unlikely	Negligible	Low
I-32	Dredge	Cadmium Sediment-disposal area	Cadmium sediment disposal - estimate includes $5,000,000 to raise an additional dike and also includes $4,500,000 worth of preparation and handling of the cadmium sediment. Cadmium sediment will be pumped by pipeline dredge into disposal area. Once material dries out additional clean dredged sediment will be used to cap it. No risk seen as far as the cost. There also is no risk during construction of intermittent pumping caused by lack of volumetric capacity. (The dredge should not have to stop to wait for the water level to go down). These costs were not singled out in the cost model.	Unlikely	Negligible	Low	$1	Unlikely	Negligible	Low
I-33	Dredging	Cadmium Sediment removal	Questioned if pumping allowed. They have to use a clamshell with an environmental type bucket to contain the material as best they can. The naturally occurring cadmium is structurally bound in the clays; it will only go into solution if it is oxidized which will occur when it is exposed and put in the disposal area. That is why it is going to be capped. Clamshell dredge probably would not be able to penetrate the material that contains the cadmium. ~~Bill Bailey to answer these questions~~. Concerns of low level cadmium may require additional measures. Pipeline dredge assumed to perform work. Cost Model assumed increase of $9mi or 30% of dredge areas with cadmium to account for risks or complications due to cadmium dredging or disposal requirements.	Likely	Significant	High	$9,000,000	Likely	Negligible	Low

I-34	Non-Dredge	Navigational Aids	Coast Guard requests several years lead time to order new equipment. Can notify now, will notify at July 8th, 2008 meeting. MARCH 2010 more detailed estimate of navigation aids provided. Due to low risk these costs were not individually modeled.	Unlikely	Negligible	Low	$1	Unlikely	Negligible	Low
I-35	Non-Dredge	PED and Construction Management Costs	Being refined this week. Potential for additional investigations borings and cadmium in mitigation. An additional cost of $1M was used in the model for this risk	Likely	Marginal	Moderate	$1,000,000	Likely	Negligible	Low
I-36	BOTH Dredge and Non-dredge	Acquisition strategy	Need acquisition plan nailed down with contracting to develop estimate based on that acquisition plan or factor in the risk based on using another method than what has been developed in the estimate itself. Need basis of estimates as far as tiering (on non-dredging work) from Tetra Tech and CH2M Hill. Need to confirm on the dike raisings what our historical has been with the Disabled Vet. Included in the estimate. November 2011 - Model considered 25% Contractors overhead to account for subcontractor acquisition or tiering.	Likely	Marginal	Moderate	25% used as Contractors Overhead	Likely	Negligible	Low
I-37	Non-Dredge	Fuel - Mitigation	Estimate uses 2.50 per gallon for off-highway Diesel based on pricing level of October 09 . Pricing updated to October 2010 as current fuel rate $2.70/gallon off-highway. Adjusted MCACES for high potential fuel cost of $6.00/gal and model includes approx $4.3 M.	Likely	Significant	High	$4,349,600	Likely	Negligible	Low
I-38	Dredging	Fuel - Dredging	~~Estimate uses $2.50 per gallon for marine Diesel based on RACK prices Oct 09~~. Pricing update as of August 2010 is approx $2.70/gallon. Upper limit would be $6.00/gallon. Model included $6/gal as high cost for dredging within CEDEP. Overall % increased shown as rough order cost.	Likely	Significant	High	increase of Hopper=25% Spider=71% Pipeline=55%	Likely	Negligible	Low

I-40	Non-Dredge	Fish Passage at Savannah River Bluff	Possible changes to underwater sheet pile, construction delaysfor flooding stream flows, in-water downstream construction windows, etc. Model considered a range of -10% to +20% as high range for this risk.	*Likely*	*Marginal*	*Moderate*	-10% to +20% of total cost.	*Likely*	*Marginal*	*Moderate*
I-41	Non-Dredge AND Dredge	Acquisition, subcontract plan, modification, claims, and residual risks.	Specific items of risk above for Non-Dredge and Dredging, were addressed separately within the risk model. Based on the current stage/level of design detail, and the consideration of over 40 specific items of risk above have been identified and quantified for potential uncertainties and assignment(s) of cost ranges of importance. Remaining items of concern such as acquisition, modifications, claims and residual risks are captured within a group range of uncertainties/inaccuracies of elements within each major phase/contract of work. This range is based on the "most Likely estimate being developed on a conservative basis as Estimator's judgment. Therefore, the cost risk analysis has assigned a -10% to +20% range for each major element/contract of cost to capture these risks within the cost model.	*Likely*	*Marginal*	*Moderate*	-10% to +20 % for all elements - contracts	Likely	Negligible	Low
External Risks (External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)										
E-1	Non-Dredge	Labor Resources	Marine contractor doing the mitigation work. PDT did not feel labor would be a risk event. This risk was not modeled.	Unlikely	Negligible	Low	$1	Unlikely	Negligible	Low
E-2	BOTH	Funding Stream	If funding comes trickling in could really extend the life of the project and seriously impact the cost. $150 M a year needed over three and a half years. Project Mgt did not feel this would be a problem considering local, state and federal interest in the project. This risk was modeled and identified as the same and shown in Item I-30.	*Likely*	*Marginal*	*Moderate*	+$9,600,000 range to - $3,000,000 same as I-30.	Likely	Negligible	Low
E-3	Dredging	Dredging Offshore	Short work season - but high belief that project can be done within the season. This risk was not modeled.	Unlikely	Negligible	Low	$1	Unlikely	Negligible	Low